International Conference on Applied Internet and Information Technologies, 2016
DOI:10.20544/AIIT2016.33

Fully Automatic MRI Brain Tumor Segmentation

Mihajlo Hasanu[1], Hristina Ambaroska[2] and Blagoj Ristevski[3]

St. Kliment Ohridski University – Bitola, Republic of Macedonia
Faculty of Information and Communication Technologies
[1]mihajlo_hasanu@yahoo.com, [2]a.hristina@hotmail.com, [3]blagoj.ristevski@fikt.edu.mk

Abstract. Today in the area of medical research, the care of brain tumor patient attracts a lot of attention. Brain tumor segmentation consists of separating the different brain tumor tissues from normal tissues. In the past, many researchers in the field of medical imaging and soft computing have made significant survey in the field of brain tumor segmentation. Both semiautomatic and fully automatic methods have been proposed. Clinical acceptance of segmentation techniques has depended on the simplicity of the segmentation and the degree of user supervision. Additionally, with the development of particular software tools for automatic segmentation and brain tumor detection, which reduce the doctors' time spent on manual segmentation, more effective and efficient results are provided. In this paper BraTumIA software tool has been used for automated segmentation on MRI brain tumor images in order to perform fully segmentation by separating different brain tumor tissues from the normal ones.

Keywords: Image Segmentation, Biomedical Engineering, MRI Brain Tumor, Medical Imaging.

1. Introduction

As the most important medium for information transmission, images allow information extracted from them to be used for further analysis. Hence, a method known as *image segmentation* helps in understanding those images and information extraction as well as the objects contained in those images. Image segmentation refers to the process of partition of a digital image into a set of regions covering the image, i.e. dividing the image in multiple segments (a set of pixels, known as superpixels) [5]. Image segmentation has two important goals. The first one is image decomposition to parts that will be used for further analysis, while the second goal is making a change in the image representation.

Image segmentation has multiple areas of application. It can be used in medical images for tumor location as well as for segmentation on organs like kidneys, heart, liver eyes; object detection; face recognition (fingerprint, iris); traffic control systems; video surveillance; computer vision; content-based image retrieval and in many other areas.

This paper is pointed towards the image segmentation applied in medicine for brain tumor segmentation using MRI images.

The rest of this paper is structured as follows. Conceptual determination of brain tumor image segmentation is discussed in Section 2, followed by the description of different types of segmentation in the Section 3 of this article. The following section describes segmentation methods, through the Section 5 an example of an automatic brain tumor

images segmentation is shown, using the software tool BraTumIA. The last section provides concluding remarks.

2. MRI Brain Tumor Segmentation

Today, brain tumor image segmentation is a highly popular research area due to the advances of new technologies. Brain tumor segmentation is an important process that provides information extraction from a complex brain MRI images. This segmentation is consisted of separating different tumor tissues as solid or active tumor, edema and necrosis from the normal brain tissues such as gray matter, white matter, and cerebrospinal fluid CSF [7].

The final goal of the brain tumor scanning and segmentation is information extraction of specific and clinically important patients, as well as their diagnostic properties. This information incorporated in data of multidimensional images can detect and localize the illness, eventually leading to a diagnosis, adequate treatment and stopping the illness.

3. Types of MRI Brain Tumor Segmentation

Image segmentation techniques can be grouped by two criteria: the level of human interaction and achieving an objective measurement for defining the homogeneity level of each tissue [1].

According to the level of human interaction, there are following three types of MRI brain tumor segmentation:

- *Manual segmentation* includes manual drawing of the brain borders and structures of interest or marking regions of anatomic structures with different labels. By this type of segmentation, experts (radiologists, anatomy specialists and trained technicians) use not only the presented information from the image, but also they need to use their additional knowledge from the particular medical area, e.g. anatomy.
- *Semiautomatic segmentation* usually needs intervention by a human operator who has a task to initialize the method, to check the accuracy of the obtained results, as well as manually correcting the segmentation results, when needed. The semiautomatic segmentation gives better, more accurate results than the manual segmentation, but shows variations in the results when the segmentation is done by different clinical experts in the same area.
- *Fully automatic segmentation* uses computers to determine the brain segmentation without human interaction. Fully automated methods, in general, include human intelligence and previous knowledge in the algorithms in a way that they use soft computing and model based techniques. Currently, the fully automated segmentation methods are desired in the processing of large series of images and are mainly restricted to the research environment [7].

According to achievement of an objective measurement for defining the homogeneity level of each tissue, there are supervised and unsupervised MRI brain tumor segmentation.

The task of the *unsupervised segmentation* is automatically finding the data structure. When data from the image is not labeled, then the image segmentation can be done using

clustering algorithms, in a way that subsets of data cannot be found or labeled in order to find predicative dependences i.e. training data. The unsupervised segmentation can be conducted using anatomically objective measurement and image based objective measurement to assess segmentation quality.

Supervised segmentation requires data delivery for training data which usually is found via drawing the regions of interest on the same image. The supervised segmentation includes a training stage for predicative dependences that uses labeled data aiming to train a model that maps features to labels and a testing stage used for assigning labels to unlabeled data based on measured features.

4. Segmentation Methods

The image segmentation techniques are classified as follows [7].

- *Threshold-based segmentation techniques* represent simple and effective methods for the region segmentation on the image, where the objects in the image are classified through comparison of their intensities with one or more intensities of the thresholds. These thresholds can be *global* (i.e. the procedure for determining light from dark regions – intensity property) or *local* (the local threshold is determined in a local region round the pixel).

- *Edge-based segmentation techniques* are used to detect edges in segmentation of images based on grey levels (gradients) effect. Edge detection is a process of finding discontinuities in an image. The edge detection methods transform the original image into image based on edges using changes on the grey levels effect of the image. Such edge detection methods are Roberts, Prewitt, Sobel, Canny, Gaussian and Laplacian of Gaussian. The interested reader is referred to [1].

- *Region-based segmentation techniques* examine the image pixels and connect neighboring pixels with homogenous properties based on prior defined criteria of pixel resemblance from unrelated regions. One such technique is the *region merging method*, used for extracting a related region with similar image pixels, starts with a single pixel or a group of pixels so-called "seeds" that belong to the region of interest. Another technique is the *watershed* technique, which represents an approach for performing a special segmentation of regions, using morphological operations on grey levels techniques [7].

- *Segmentation techniques using pixel classification* are restricted on using only unsupervised and supervised classifiers to cluster pixels in the feature space. Clustering is a process of unsupervised learning about grouping of similar items into a single cluster, while objects with different characteristics are grouped in different clusters based on some conditions of resemblance. An example of such technique is *k*-means clustering that groups *n* pixels closest to the cluster's centroid [4]. Fuzzy clustering can be used in cases when there are no defined borders between different objects in the image. Fuzzy clustering divides the input pixels into a single cluster or a group of clusters based on some resemblance criteria such as distance, connection, intensity, etc.

5. BraTumIA

BraTumIA is a software tool used for *automatic* analysis of brain tumor images, developed by Institute for Surgical Technology & Biomechanics [8]. This tool can perform tumor segmentation including its sub-compartments of MRI images of people that have glioma. It needs four different MRI image sequences T1, T1 contrast, T2 and Fluid Attenuated Inversion Recovery (FLAIR) to be able to perform an effective and efficient automatic brain tumor image segmentation [8].

The images are processed using a pipeline approach, where skull-stripping is performed first in order to generate a brain mask. Subsequently, all images are co-registered to ensure voxel-to-voxel correspondence between the different MRI sequences. Based on these registered images, a segmentation of the patient images into healthy and tumor tissues is done based on combined classification and regularization. This produces a label map and quantitative information about tissue volumes. Healthy subcortical structures are segmented using a deformable registration of an atlas to the patient image. Finally, the label maps can be transformed back into the original space of each image sequence so that they can be shown as an overlay on the original images.

Aiming to approach the software functionality, these four image sequences need to be loaded by specifying their locations in the testing folder that contains the data sets saved on a set location. In the process of setting the locations, a specific location needs to be set for each of the four sequence modalities and additional one for the location of the folder containing the output results. The data sets used for testing images are downloaded from the Neuroimaging Informatics Tools and Resources Clearinghouse (NITRC) where the software itself, can be found as well [9]. Fig. 1 shows the images for the four sequences in the main software window, shown clockwise, starting with T1 in the top left corner, T1c in the top right corner, T2 in the bottom right corner, and FLAIR in the bottom left corner.

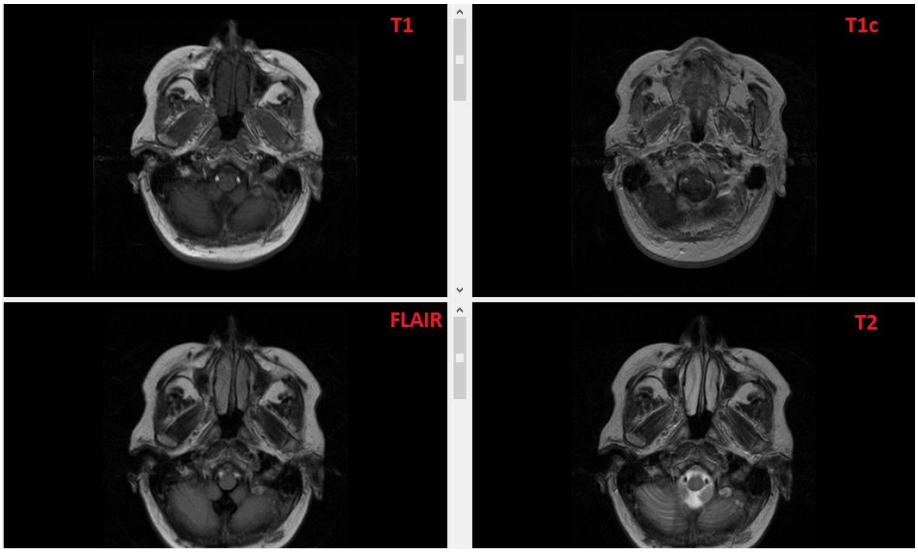

Fig. 1. Sequences representation in the four visualization sub-windows in BraTumIA.

5.1. Data Processing and the Results' Visualization

For data processing, the user can refer to any segmentation module separately or a full segmentation for all modules: skull-striping, multimodal registration and classification. The *skull-striping* module allows creating a brain mask that can be adjusted in the desired position i.e. creation of registered versions of images. The *multimodal registration* module allows getting a correspondence between the segmented regions, while the *classification* module allows tissue and structure classification, for the healthy and diseased brain regions as well as their volume of the total brain volume. Fig. 2 represents the original *vs* registered MRI image.

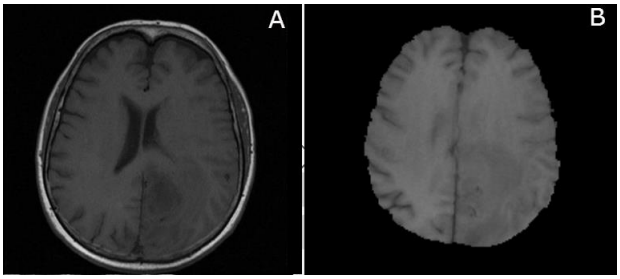

Fig. 2. (A) Original version of the image vs. (B) registered version of the image.

After performing the data processing in the background by using suitable algorithms implemented in this software for automated segmentation, in the main window for visualization, label maps in different colors are shown as an overlay on the original or registered version of the image. In this particular case the modality T1 is chosen. This kind of label maps actually represents the performed image segmentations in regions related to the tumor tissue. The segmentation results are shown on Fig. 3.

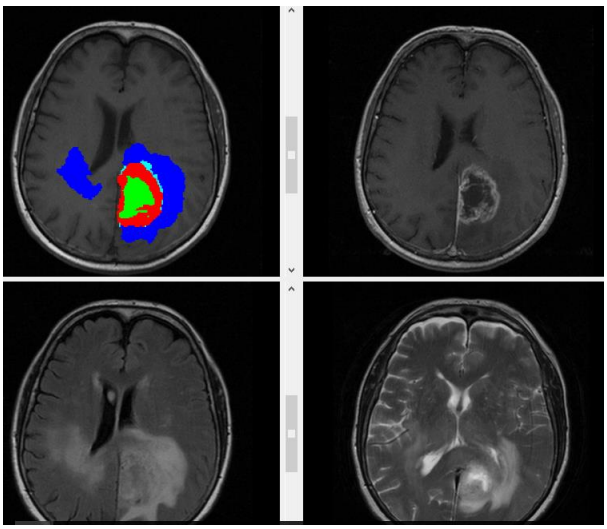

Fig. 3. Segmentation performed for T1 modality.

The BraTumIA software allows additional activities, such image multi-scrolling, zooming in on images, as well as adjusting the contrast intensity of the images. By adjusting the contrast intensity for the chosen modality T1 with a small mouse movement to the left or to the right, an extraction will be done only to the part containing the tumor tissue, as shown on Fig. 4.

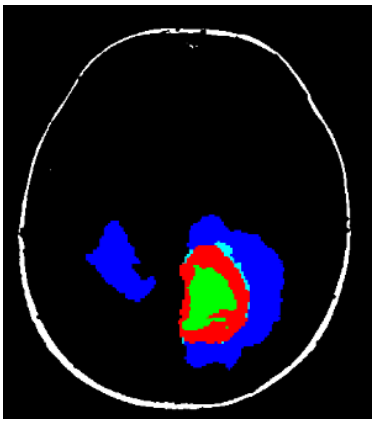

Fig. 4. Extracted part of segmentation for T1 modality.

If it is needed to see the volume of the healthy and cancer tissue regarding to the total brain mass, then such information can be accessed and presented to the user by pressing the *Segmentation Table* button which triggers opening a new window. In this window the volume for each tissue (gray matter, white matter, and cerebrospinal fluid, necrotic tissue, enhancing and non-enhancing tumor tissues and edema) is given measured in cm^3. Additionally, by clicking each of the tissues' names a full brain tumor segmentation is presented, i.e. separation of the healthy from the tumor infected tissue. Fig. 5 shows the volume of each tissue from the brain volume (A) and fully automatic segmentation performed of healthy and diseased brain tissues (B).

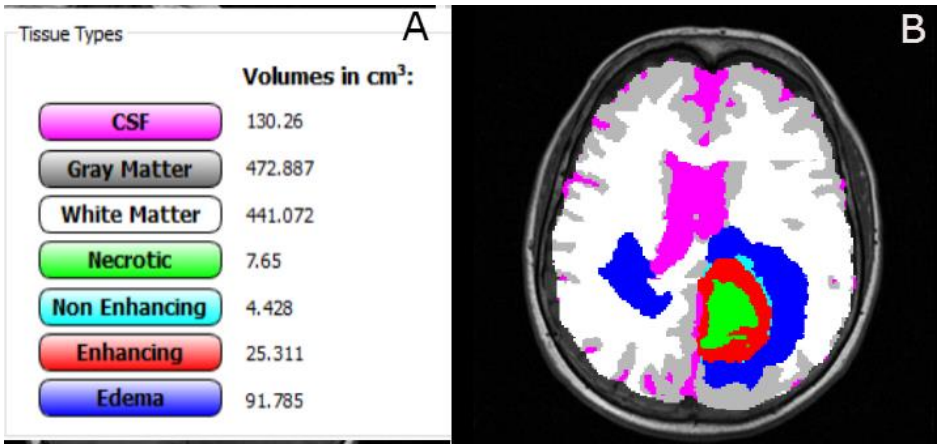

Fig. 5. (A) Segmentation table window that shows the volumes for each segmented tissue compartment and (B) fully segmentation performed for each tissue.

6. Conclusion

Today, in the area of biomedical research, the care of patients suffered from brain tumor gets a lot of attention. There are a plethora of software packages developed for automatic segmentation and brain tumor detection that reduces the doctors' time spent on manual segmentation. StripTs, iSix, FISICO, Di2Mesh, Point Wise Multimodal Demons Registration, Brain tissue segmentation are examples of software tools for MRI segmentation and analysis. The automatic brain tumor segmentation offers numerous benefits for the medicine. There are many methods used for brain tumor segmentation providing the doctors with detailed, precise and complete aspects of the brain tumor and help them to diagnose and choose the best treatment for healing the tumors.

In this research, *BraTumIA* was chosen as a tool for automatic brain tumor segmentation which gives as a result successfully performed tumor tissue segmentation compared to the normal brain tissue. Furthermore, this tool provides detailed and complete information about the volume of the tumor and normal tissue regarding to the total brain volume. For this purpose, in this paper a testing data set has been used which contains MRI images for all four modalities T1, T1c, T2 and FLAIR.

Although this tool provides a lot of advantages for medical usage and implementation, there is a still challenging task to develop some modules of this software package to allow maximum functionality for the MRI tumor segmentation.

References

[1] Jobin Christ MC.: Segmentation and classification of brain tumors using hierarchical topology preserving map. Anna University, Faculty of Information and Communication Engineering (2013).

[2] Sushovan Mandal.: Brain tumor detection using mathematical morphology and density approximation approach. Dissertation, Jadavpur University, Faculty of Engineering and Technology (2010).

[3] A.M. Khan, Ravi. S.: Image Segmentation Methods: A Comparative Study. International Journal of Soft Computing and Engineering, ISSN: 2231-3207, Volume-3, Issue-4. (2013)

[4] Ruchi D. Deshmukh, Chaya Jadhav.: Study of Different Brain Tumor MRI Image Segmentation Techniques. International journal of Computer Science Engineering and Technology, Volume-4, Issue-4 (2014).

[5] Linda G. Shapiro, George C. Stockman.: Computer Vision – Chapter 10: Image Segmentation. University of Washington (2000).

[6] Sudipta Roy, Sanjay Nag.: A Review on Automated Brain Tumor Detection and Segmentation from MRI of Brain. International journal of Advanced Research in Computer Science and Software Engineering, Volume-3, Issue-6 (2013).

[7] Nelly Gordillo, Eduard Montseny.: State of the art survey on MRI brain tumor segmentation. Review article on Magnetic Resonance Imaging (2013).

[8] S. Bauer, T. Fejes, R. Meier, M. Reyes, J. Slotboom, N. Porz, A. Pica, and R. Wiest.: BraTumIA – A software tool for automatic Brain Tumor Image Analysis (2013).

[9] https://www.nitrc.org